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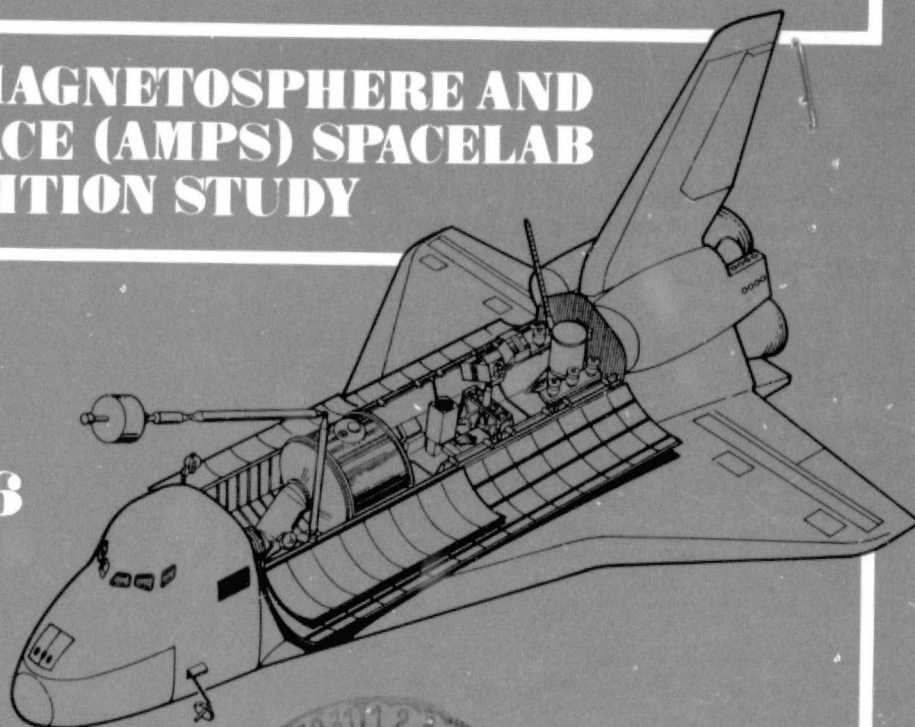
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ATMOSPHERE; MAGNETOSPHERE AND PLASMAS IN SPACE (AMPS) SPACELAB PAYLOAD DEFINITION STUDY

Final Report November 1976



Prepared for
National Aeronautics
and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

**TRW**

DEFENSE AND SPACE SYSTEMS GROUP

ATMOSPHERE, MAGNETOSPHERE AND PLASMAS IN SPACE (AMPS)
SPACELAB PAYLOAD DEFINITION STUDY
FINAL REPORT

VOLUME II
MISSION SUPPORT REQUIREMENTS DOCUMENT
ADDENDUM - FLIGHT 2

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November 1976

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Prepared for
National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771
Contract No. NAS8-31690



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A1. INTRODUCTION

- A1.1 PURPOSE. The purpose of this appendix is to define the AMPS Flight 2 payload, its operation, and the support required from the Space Transportation System (STS). The definition of the payload includes the flight objectives and requirements, the experiment operations, and the payload configuration. The support required from the STS includes the accommodation of the payload by the Orbiter/Spacelab, use of the flight operations network and ground facilities, and the use of the launch site facilities.
- A1.2 FLIGHT OBJECTIVES. The scientific objective of the AMPS program is to assist in developing a comprehensive understanding of the region surrounding the earth. Based on laboratory and space experimentation, several techniques for meeting this goal have been proposed. These techniques involve observing the effects produced by natural processes or by disturbances that are purposely imposed. Flight 2 experiments have been chosen that utilize these techniques and cover a broad range of investigations. The range of AMPS investigations has been apportioned into three disciplines -- plasma interaction and flow, wave phenomena, and atmospheric science. Active experiments in each of these areas are included in the Flight 2 experiment list, as described below.

A1.2.1 The plasma interaction and flow discipline for Flight 2 is represented by a conductivity modification and a measurement of the plasma flow about a test body. In the conductivity modification experiment the effect of gross changes in ionospheric conductivity by injecting a large quantity of ionizable material in the auroral zone will be investigated. The increase in conductivity will modify the natural ionospheric and magnetospheric currents. This leads to enhanced field-aligned and perpendicular currents, enhanced particle precipitation, and the possible triggering of an aurora or substorm. Observations of the effects will be made by a suitable ground station (such as Fort Churchill), by Spacelab-mounted diagnostic sensors, and by remotely-located sensors. In the plasma flow measurements experiment, an attempt will be made to create and measure the plasma flow around a symmetrical conducting test body which can be biased to any electric potential relative to the local plasma. The test body will be a 10-meter diameter spherical balloon made of aluminized mylar or other conducting material. It will be mounted on a mast so maneuvering of the Orbiter and the group of diagnostic instruments will make it possible to map the properties of its wake at distances from a fraction of the radius up to several radii from the surface of the test body, at nearly all azimuthal angles from the plasma flow velocity vector. This will produce a three-dimensional map of the electron and ion densities and temperatures in the perturbed region.

A1.2.2 In the wave phenomena category, investigations on Flight 2. For this flight, two classes of wave experiments will be performed. The first class will consist of investigations that use the natural ionospheric plasma as a plasma physics laboratory with a collision-free, boundary-free, homogeneous plasma on a very large scale. Wave dispersion, wave particle and wave-wave interactions, plasma turbulence, and plasma wave instabilities will be studied using the RF sounder operating at continuous powers up to 100 watts and peak powers up to 10 kW. In particular, wave propagation at frequencies from 30 kHz to 20 MHz will be studied as a function of magnetic field orientation, ionospheric density, and frequency. An attempt will be made to saturate the transmission properties of the ionosphere so that plasma instabilities will be generated. The second class will consist of investigations using the RF transmitter in a search for, and detection of long delayed echoes. In this experiment, sounding echoes that are delayed for 10 seconds or more are deflected from the ionosphere and the echoes will be detected with the receiver, on the ESP.

A1.2.3 Atmospheric investigations will be made in three areas. First, a hard-mounted lidar will be used to make ozone density measurements using a dual beam differential absorption technique. Second, an atmospheric array will perform limb scanning measurements to provide a worldwide map for a large number of molecular species in the upper atmosphere. Maps will be made of the molecular concentration and temperatures of chlorine oxide, nitric oxide, and the hydroxyl radical that are involved in the production and destruction of ozone. In addition to the lidar and limb scanning surveys, Flight 2 will be prepared to make observations of certain intermittent natural phenomena that contribute to the ozone balance of the atmosphere. An example of this type of experiment is the study of high latitude changes in ozone density caused by the bombardment of the polar cap atmosphere by energetic solar protons during a severe proton event. These solar proton events are relatively rare, usually less than one per month, but during the event, it is thought that very large amounts of ozone are destroyed in the polar cap regions. Another target of opportunity investigation is measurement of changes in the ambient density of major atmospheric constituents caused by high latitude energetic particle bombardment.

A1.3 FLIGHT REQUIREMENTS. The flight objectives for the experiment disciplines were defined in A1.2. The requirements to meet those objectives are summarized here. The following sections define the requirements for the disciplines — plasma interaction and flow, wave phenomena, and atmospheric science.

- A1.3.1 The plasma interaction and flow experiments include a barium release, ionospheric conductivity modification experiment, and a plasma flow measurements experiment.
- A1.3.1.1 The experiment requires the barium canister ignition over a high latitude auroral zone ground station. The ignition is to be achieved at twilight during low auroral and magnetic activity. The canister will be released and placed in an orbit that locates it 20 km below and 1000 km ahead of the Orbiter at ignition. This will allow measurements of electric fields, particle densities, and OBIPS observation as the Orbiter passes over the expanding gas cloud.
- A1.3.1.2 The plasma flow measurements experiment will require a balloon test body attached to the end of the 15-meter mast. The balloon will be inflated by a gas canister to 10 meters in diameter. The RMS, containing such diagnostics as a Langmuir probe, an ion mass and distribution analyzer, a neutral mass spectrometer and a magnetometer, is erected and trailed in the wake of the test body. Coordinated motion and rolling of the Orbiter and the RMS will provide variations in the wake characteristics of the test body. At the end of the experiment, the balloon will be jettisoned. By performing the measurements of different orbital latitudes, the flow characteristics as a function of the angle between the magnetic field angle and the Orbiter velocity vector will be studied.
- A1.3.2 The wave phenomena experiments require the deployment and alignment of the RF transmitter perpendicular to the magnetic field line. The transmitted signals interact with the local plasma and must be detected by the ESP-mounted receiver. The ESP is to be placed outside the electromagnetic environment of the Orbiter. For the long delay echo experiment, the ESP must trail the Orbiter by 10 seconds or 80 km. The experiment is to be conducted at an altitude of at least 300 km.
- A1.3.3 The atmospheric experiments include ozone measurements, minor constituents, solar flux monitor and several targets of opportunity.
- A1.3.3.1 The ozone measurements require the lidar to be used in the downward viewing mode, pointing to within 10 degrees of the nadir. The ozone measurements can be performed at any time, and will in fact best be carried out by using a variety of geographic locations. Initial test firings, however, would best be performed in the dark to minimize any problems with background radiation.

A1.3.3.2 The atmospheric minor constituents experiments require scanning the earth's limb, but can be performed at any time so long as the sun is not in the field of view. The solar flux monitor will view the sun's disk once per day at local noon. Since the limb scanning instruments are also mounted on the SIPS, these must be shut down and closed off during this period of time. The solar viewing is best performed at the flight's maximum altitude (to minimize atmospheric absorption) and during periods of minimum outgassing and effluents release.

A1.3.3.3 The atmospheric targets of opportunity experiments require as high a latitude as possible to maximize the overflight of the auroral zone.

A1.4 SUCCESS CRITERIA. The success of the flight is based on the achievement of specific events within each of the four investigation areas. These events are given a category rating. The investigations will be considered a success if each of Category 1 events are achieved during the flight.

<u>Investigation Area</u>	<u>Category</u>
Particle interactions	
Produce RF plasma waves	(TBD)
Receive returns with deployed ESP	(TBD)
Produce usable data	(TBD)
Receive long delayed echoes	(TBD)
Chemical release	
Produce observable release	(TBD)
Produce usable data	(TBD)
Observe conductivity changes	(TBD)
Produce an artificial aurora	(TBD)
Observe magnetic/electric field changes	(TBD)
Plasma flow	
Mapping electromagnetic radiation	(TBD)
Mapping pressure and composition	(TBD)
Mapping ion, electron densities and temperatures	(TBD)

Investigation Area

Category

Atmospheric Science

Send and receive lidar signal (TBD)

Complete lidar soundings (TBD)

Successfully cool IR instruments (TBD)

Perform a series of limb scans and
obtain interferometer data (TBD)

Complete limb scans (TBD)

Perform solar flux monitor experiments (TBD)

A1.5 APPLICABLE DOCUMENTS. The documents identified for Flight 1 are also required for Flight 2.

A2 EXPERIMENT OPERATIONS

During the second flight of the AMPS payload 10 experiments will be performed in order to study the atmosphere, magnetosphere, and to investigate plasma phenomena in the ionosphere. The following is a list of the experiments:

- (1) Low altitude conductivity modification
- (2) High frequency wave interactions
- (3) Long delay echoes
- (4) Plasma flow
- (5) Minor constituents
- (6) D-region composition changes
- (7) Oxygen variations
- (8) Neutral composition near aurora
- (9) Ozone changes at high latitude
- (10) Solar flux calibration.

Experiment 1 uses a multiple barium release to achieve increased conductivity in the ionosphere. Experiments (2) and (3) use the RF sounder to produce waves in the ionospheric plasma. Experiment (4) measures the wake of a conducting spherical test body. Experiments (5), (6), (7), (8) and (9) use the lidar and remote sensing optical instruments to determine the properties of the atmosphere in the region between 20 and 100 kilometers altitude. Experiment (10) is performed for 30 minutes near local noon six times during the flight to check the absolute solar intensity at the top of the atmosphere.

A2.1 EXPERIMENT SEQUENCE DEFINITIONS. The following list of steps involved in the carrying out of each of the experiments for flight 2 have been broken down into rather large general steps rather than into detail, explicit operations. A list of detailed operations would be at least 10 times as long as this general listing of operations. The definitions of the operations are somewhat cryptic and assume that the reader is already reasonably familiar with the kinds of experiments and equipment that are being used.

A2.1.1 Low altitude conductivity modification

- (1.1) Check release canister: Make sure that the barium release mechanism is in working order and ready for ejection from the Orbiter.
- (1.2) Orient the Orbiter for ejection of the canister: The canister will be spring ejected into the proper orbit so that when the canisters are fired they will be at the right altitude and position.

- (1.3) Check diagnostic instruments: Make sure that the magnetometer, Langmuir probe, ion mass and distribution analyzer, and OBIPS are turned on and functioning properly.
- (1.4) Orient Orbiter: Orient the Orbiter so that when the barium canisters are fired, the OBIPS can view them and the ambient ionospheric measuring instruments will not be in the Orbiter wake region.
- (1.5) Orient SIPS: Orient the SIPS so that the OBIPS can look at the barium release.
- (1.6) Fire barium canisters: Initiate the thermite reaction.
- (1.7) Take data: Take data with the OBIPS, magnetometer, Langmuir probe, and ion mass and distribution analyzer for as long as the release region is visible.
- (1.8) Shut down: Turn off all the instruments and release the SIPS and Orbiter for other experiments.

A2.1.2 High frequency wave interaction

- (2.1) Check ESP: Make sure that the ESP instruments are in proper condition, that the ESP telemetry system is operational and that the ejection mechanism is operational.
- (2.2) Orient Orbiter: Orient the Orbiter so that the ESP can be ejected into the proper orbit.
- (2.3) Eject ESP: Eject the ESP from the Orbiter into the correct orbit.
- (2.4) Erect the mast: Erect the 15-meter RF sounder mast.
- (2.5) Check RF sounder: Make sure that the RF sounder is in proper operational condition.
- (2.6) Orient Orbiter: Put the Orbiter in the right attitude so that waves can be transmitted from the RF sounder to ESP detectors, and ESP telemetry can be received.
- (2.7) Orient RF sounder antenna: Put the antenna into the desired orientation.
- (2.8) Radiate with the RF sounder: Pick proper radiation conditions, power, frequency, etc., and generate waves.
- (2.9) Take data: Use the ESP receivers to measure the wave transmission and interaction properties.
- (2.10) Repeat: Repeat (2.5) through (2.9) at various RF sounder settings and ESP positions.
- (2.11) Shut down: Turn off RF sounder, release Orbiter and ESP for other experiments.

A2.1.3 Long delay echoes

- (3.1) Check ESP: Assuming the ESP has been deployed for experiment (2), regain telemetry contact and make sure instruments are operational.
- (3.2) Orient Orbiter: Orient Orbiter so that RF waves will be transmitted in proper direction and telemetry contact with ESP can be maintained.
- (3.3) Check RF sounder: Check to see that RF sounder is operational, set up proper frequencies and powers for transmission experiment.
- (3.4) Orient RF sounder antenna: Put antenna into proper orientation for echo experiment.
- (3.5) Transmit RF waves: Activate RF sounder transmission.
- (3.6) Take data: Use the ESP receiver to look for the long delay echoes of the transmitted waves.
- (3.7) Repeat: Repeat (3.2) through (3.6) at various frequencies, powers, and ESP distances, Orbiter locations.
- (3.8) Shut down: Turn off RF sounder, release Orbiter and ESP for other experiments.

A2.1.4 Plasma flow

- (4.1) Check test body: Assuming that the 15-meter mast has been deployed, inflate test body and verify electrical connections and proper shape.
- (4.2) Check diagnostic instruments: Make sure that the Langmuir probe, ion mass and distribution analyzer, magnetometer, neutral mass spectrometer and OBIPS are in proper operational condition.
- (4.3) Orient Orbiter: Orient the Orbiter into various positions so that wake data can be taken.
- (4.4) Check out RMS: Make sure that the RMS is operational.
- (4.5) Position RMS: Put RMS in various positions so that diagnostic instruments can take data.
- (4.6) Take data: Record the data from the various diagnostics.
- (4.7) Repeat: Repeat (4.3) through (4.6) at various test body, flow velocity, RMS positions.
- (4.8) Shut down: Turn off diagnostics, jettison test body if experiment is finished, release RMS and Orbiter for other experiments.

A2.1.5 Minor constituents

- (5.1) Check lidar system: Start dye pump, charge capacitor bank, align and tune lasers, check all housekeeping monitors, turn on receiver detector, check receiver alignment. Calibrate if possible.
- (5.2) Cool IR system: Begin the cooling process of the cryogenically cooled IR telescope and the IR detectors.
- (5.3) Check the optical systems: Once IR instruments are cold, turn them on and check for proper operational conditions. Also check the UV-Vis-NIR photospectrometers for proper operation.
- (5.4) Orient Orbiter: Put the Orbiter in such a position that the SIPS can do limb scanning while the lidar system is doing soundings.
- (5.5) Orient the SIPS: Put the SIPS in an earth limb scanning mode.
- (5.6) Test fire lasers: Fire lidar into atmosphere and check firing systems, receiver output, laser outputs, alignments, power consumption, laser and receiver tunings.
- (5.7) Take data: Collect data with the IR instruments, the UV-Vis-NIR in the limb scanning mode for long periods of time in order to build up a map of the various atmospheric emissions. Begin firing the lidar on automatic mode for sounding data up to 2 pulses per second.
- (5.8) Examine data: Periodically check to see that the data being collected by all the instruments has the proper qualitative features.
- (5.9) Shut down: Deactivate all of the instruments and release the SIPS and the Orbiter for other experiments.

A2.1.6 D-region composition changes

- (6.1) Coordinate observations: In this experiment it is important that there be significant geomagnetic storm activity before the experiment is performed. Communications with geomagnetically northern ground stations and other space observing platforms will be needed so that this experiment can be put into action if the proper opportunities exist.
- (6.2) Check instruments: Make sure that the lidar, the UV-VIS-NIR photometers and the IR spectrometer are all operating properly.
- (6.3) Orient Orbiter: In coordination with the ground observations or with past AMPS observations, orient the Orbiter so that the SIPS will be able to follow the regions affected by the geomagnetic activity.

- (6.4) Orient SIPS: SIPS must be controlled by a man who is looking at one of the Visible photometer outputs so that the instruments can be continually pointed at the proper emission region.
- (6.5) Take data: During the time that the region of interest is in view, data should be obtained from all the instruments. The man must continually monitor the quality of this data.
- (6.6) Shut down: Turn the instruments off, release the SIPS and the Orbiter for other experiments.

A2.1.7 Oxygen variations

- (7.1) Coordinate observations: Same as (6.1).
- (7.2) Check instrument: Make sure that the UV-Vis-NIR photometers are set to the proper wavelength and are in operational order.
- (7.3) Orient Orbiter: The Orbiter will be oriented so that the photometers can track the regions where there has been activity.
- (7.4) Orient SIPS: SIPS must be controlled by a man who is following the output of the photometers so that the instruments can be pointed at the proper emission regions.
- (7.5) Take data: During the time that the region of interest is in view, data should be obtained from the photometers and the quality of the data must be continually monitored.
- (7.6) Shut down: Turn the instruments off, release the SIPS and the Orbiter for other experiments.

A2.1.8 Neutral composition near the aurora

- (8.1) Same as (6.1).
- (8.2) Check instruments: Make sure that the lidar, OBIPS, UV-Vis-NIR photometers, and the near IR spectrometer are all functioning properly, check ESP instrument if available.
- (8.3) Orient Orbiter: The Orbiter will be oriented so that the OBIPS and the other optical instruments will be able to track the auroral activity regions, and receive ESP telemetry.
- (8.4) Orient SIPS: SIPS must be controlled by a man who is following the OBIPS output so that the instruments will track the active regions.
- (8.5) Take data: During the time that the active auroral regions are in view, data should be obtained from all the instruments and the quality of the data must be continually monitored.
- (8.6) Shut down: Turn the instruments off, release the SIPS and the Orbiter for other experiments.

A2.1.9 Ozone changes at high latitude

- (9.1) Coordinate observations: This experiment would measure the changes of ozone during and after a PCA (polar cap absorption, i.e., severe proton) event. It will be necessary that close coordination with ground stations be maintained in order to determine the extent and magnitude of the PCA event as well as its character.
- (9.2) Check instruments: Make sure that the lidar, UV-Vis-NIR photometers, IR interferometer and limb scanning radiometer are in proper operating condition.
- (9.3) Orient Orbiter: Orient the Orbiter so that the instruments will be able to make limb scans to the geomagnetic north of the vehicle and the lidar can do soundings.
- (9.4) Orient SIPS: Put SIPS into a limb scanning mode, and where possible, align the scans with the magnetic meridians.
- (9.5) Take data: During the period that the region stimulated by the PCA event is visible, take data from all of the instruments and continuously monitor the quality of the data.
- (9.6) Shut down: Turn all instruments off, and release the SIPS and the Orbiter for other experiments.

A2.1.10 Solar flux calibration

- (10.1) Check solar flux instrument: Turn instrument on, check performance and housekeeping monitors. If there is a calibration cycle, perform it.
- (10.2) Orient Orbiter: Orient the Orbiter so that the SIPS will be able to view the sun.
- (10.3) Orient SIPS: Put the SIPS into a mode whereby it will allow the solar flux monitor to center on the sun for periods of up to 15 minutes each.
- (10.4) Take data: Turn the solar flux instrument on for a period long enough to gather 30 minutes worth of data when the sun is within 45 degrees of the zenith. The data can be transmitted to the ground directly or stored. There is little crew interaction with the experiment once it has started.
- (10.5) Shut down: Turn instrument off, and release the SIPS and the Orbiter for other experiments.

A2.2 EXPERIMENT ORBITAL CONSTRAINTS AND REQUIREMENTS

Step No.		Orbit Inclination	Altitude	Altitude	Time of Day	Time of Flight	Geographic Position
	Low altitude Conductivity modification						
(1.1)	Check release canister	TBD	TBD	TBD	TBD	TBD	TBD
(1.2)	Orient the Orbiter for ejection						
(1.3)	Check diagnostic instruments						
(1.4)	Orient Orbiter						
(1.5)	Orient SIPS						
(1.6)	Fire barium canisters						
(1.7)	Take data						
(1.8)	Shut down						
	High frequency wave interaction						
(2.1)	Check ESP	TBD	TBD	TBD	TBD	TBD	TBD
(2.2)	Orient Orbiter						
(2.3)	Eject ESP						
(2.4)	Erect the mast						
(2.5)	Check RF sounder						
(2.6)	Orient Orbiter						
(2.7)	Orient RF sounder antenna						
(2.8)	Radiate with the RF sounder						
(2.9)	Take data						
(2.10)	Repeat (2.5) through (2.9)						
(2.11)	Shut Down						

Step No.	Instruments Used	Orbit Inclination	Altitude	Altitude	Time of Day	Time into Flight	Geographic Position
	Long delay echoes						
(3.1) (3.2) (3.3) (3.4) (3.5) (3.6) (3.7) (3.8)	Check ESP Orient Orbiter Check RF sounder Orient RF sounder antenna Transmit RF waves Take data Repeat (3.2) through (3.6) Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	Plasma flow						
(4.1) (4.2) (4.3) (4.4) (4.5) (4.6) (4.7) (4.8)	Check test body Check diagnostic instruments Orient Orbiter Check out RMS Position RMS Take data Repeat (4.3) through (4.6) Shut down	TBD	TBD	TBD	TBD	TBD	TBD

Step No.	Instruments Used	Orbit Inclination	Altitude	Altitude	Time of Day	Time into Flight	Geographic Position
	Minor Constituents						
(5.1)	Check Lidar system	TBD	TBD	TBD	TBD	TBD	TBD
(5.2)	Cool IR system						
(5.3)	Check the optical system						
(5.4)	Orient Orbiter						
(5.5)	Orient the SIPS						
(5.6)	Test fire lasers						
(5.7)	Take data						
(5.8)	Examine data						
(5.9)	Shut down						
	D-region composition changes						
(6.1)	Coordinate observations	TBD	TBD	TBD	TBD	TBD	TBD
(6.2)	Check instruments						
(6.3)	Orient Orbiter						
(6.4)	Orient SIPS						
(6.5)	Take data						
(6.6)	Shut down)						
	Oxygen variations						
(7.1)	Same as (6.1)	TBD	TBD	TBD	TBD	TBD	TBD
(7.2)	Check instrument						
(7.3)	Orient Orbiter						
(7.4)	Orient SIPS						
(7.5)	Take data						
(7.6)	Shut down						

Step No.	Instruments Used	Orbit Inclination	Altitude	Altitude	Time of Day	Time of Flight	Geographic Position
	Neutral composition near the aurora						
(8.1) (8.2) (8.3) (8.4) (8.5) (8.6)	Same as (6.1) Check instruments Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	Ozone changes at high altitude						
(9.1) (9.2) (9.3) (9.4) (9.5) (9.6)	Coordinate observations Check instruments Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	Solar flux calibration						
(10.1) (10.2) (10.3) (10.4) (10.5)	Check solar flux instrument Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD

A2.3 EXPERIMENT OPERATIONS CONSTRAINTS AND REQUIREMENTS

Step No.		Orbit Inclination	Altitude	Altitude	Time of Day	Time of Flight	Geographic Position
	Low altitude Conductivity modification						
(1.1) (1.2) (1.3) (1.4) (1.5) (1.6) (1.7) (1.8)	Check release canister Orient the Orbiter for ejection Check diagnostic instruments Orient Orbiter Orient SIPS Fire barium canisters Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	High frequency wave interaction						
(2.1) (2.2) (2.3) (2.4) (2.5) (2.6) (2.7) (2.8) (2.9) (2.10) (2.11)	Check ESP Orient Orbiter Eject ESP Erect the mast Check RF sounder Orient Orbiter Orient RF sounder antenna Radiate with the RF sounder Take data Repeat (2.5) through (2.9) Shut Down	TBD	TBD	TBD	TBD	TBD	TBD

Step No.	Instruments Used	Orbit Inclination	Altitude	Altitude	Time of Day	Time into Flight	Geographic Position
	Long delay echoes						
(3.1) (3.2) (3.3) (3.4) (3.5) (3.6) (3.7) (3.8)	Check ESP Orient Orbiter Check RF sounder Orient RF sounder antenna Transmit RF waves Take data Repeat (3.2) through (3.6) Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	Plasma flow						
(4.1) (4.2) (4.3) (4.4) (4.5) (4.6) (4.7) (4.8)	Check test body Check diagnostic instruments Orient Orbiter Check out RMS Position RMS Take data Repeat (4.3) through (4.6) Shut down)	TBD	TBD	TBD	TBD	TBD	TBD

Step No.	Instruments Used	Orbit Inclination	Altitude	Altitude	Time of Day	Time into Flight	Geographic Position
	Minor Constituents						
(5.1) (5.2) (5.3) (5.4) (5.5) (5.6) (5.7) (5.8) (5.9)	Check Lidar system Cool IR system Check the optical system Orient Orbiter Orient the SIPS Test fire lasers Take data Examine data Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	D-region composition changes						
(6.1) (6.2) (6.3) (6.4) (6.5) (6.6)	Coordinate observations Check instruments Orient Orbiter Orient SIPS Take data Shut down)	TBD	TBD	TBD	TBD	TBD	TBD
	Oxygen variations						
(7.1) (7.2) (7.3) (7.4) (7.5) (7.6)	Same as (6.1) Check instrument Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD

Step No.	Instruments Used	Orbit Inclination	Altitude	Altitude	Time of Day	Time of Flight	Geographic Position
	Neutral composition near the aurora						
(8.1) (8.2) (8.3) (8.4) (8.5) (8.6)	Same as (6.1) Check instruments Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	Ozone changes at high altitude						
(9.1) (9.2) (9.3) (9.4) (9.5) (9.6)	Coordinate observations Check instruments Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	Solar flux calibration						
(10.1) (10.2) (10.3) (10.4) (10.5)	Check solar flux instrument Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD

A2.4 INSTRUMENT OPERATIONAL CONSTRAINTS

Step No.		Orbit Inclination	Altitude	Altitude	Time of Day	Time of Flight	Geographic Position
	Low altitude Conductivity modification						
(1.1)	Check release canister	TBD	TBD	TBD	TBD	TBD	TBD
(1.2)	Orient the Orbiter for ejection						
(1.3)	Check diagnostic instruments						
(1.4)	Orient Orbiter						
(1.5)	Orient SIPS						
(1.6)	Fire barium canisters						
(1.7)	Take data						
(1.8)	Shut down						
	High frequency wave interaction						
(2.1)	Check ESP	TBD	TBD	TBD	TBD	TBD	TBD
(2.2)	Orient Orbiter						
(2.3)	Eject ESP						
(2.4)	Erect the mast						
(2.5)	Check RF sounder						
(2.6)	Orient Orbiter						
(2.7)	Orient RF sounder antenna						
(2.8)	Radiate with the RF sounder						
(2.9)	Take data						
(2.10)	Repeat (2.5) through (2.9)						
(2.11)	Shut Down						

Step No.	Instruments Used	Orbit Inclination	Altitude	Altitude	Time of Day	Time into Flight	Geographic Position
	Long delay echoes						
(3.1)	Check ESP	TBD	TBD	TBD	TBD	TBD	TBD
(3.2)	Orient Orbiter						
(3.3)	Check RF sounder						
(3.4)	Orient RF sounder antenna						
(3.5)	Transmit RF waves						
(3.6)	Take data						
(3.7)	Repeat (3.2) through (3.6)						
(3.8)	Shut down						
	Plasma flow						
(4.1)	Check test body	TBD	TBD	TBD	TBD	TBD	TBD
(4.2)	Check diagnostic instruments						
(4.3)	Orient Orbiter						
(4.4)	Check out RMS						
(4.5)	Position RMS						
(4.6)	Take data						
(4.7)	Repeat (4.3) through (4.6)						
(4.8)	Shut down)						

Step No.	Instruments Used	Orbit Inclination	Altitude	Altitude	Time of Day	Time into Flight	Geographic Position
	Minor Constituents						
(5.1) (5.2) (5.3) (5.4) (5.5) (5.6) (5.7) (5.8) (5.9)	Check Lidar system Cool IR system Check the optical system Orient Orbiter Orient the SIPS Test fire lasers Take data Examine data Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	D-region composition changes						
(6.1) (6.2) (6.3) (6.4) (6.5) (6.6)	Coordinate observations Check instruments Orient Orbiter Orient SIPS Take data Shut down)	TBD	TBD	TBD	TBD	TBD	TBD
	Oxygen variations						
(7.1) (7.2) (7.3) (7.4) (7.5) (7.6)	Same as (6.1) Check instrument Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD

Step No.	Instruments Used	Orbit Inclination	Altitude	Altitude	Time of Day	Time of Flight	Geographic Position
	Neutral composition near the aurora						
(8.1) (8.2) (8.3) (8.4) (8.5) (8.6)	Same as (6.1) Check instruments Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	Ozone changes at high altitude						
(9.1) (9.2) (9.3) (9.4) (9.5) (9.6)	Coordinate observations Check instruments Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD
	Solar flux calibration						
(10.1) (10.2) (10.3) (10.4) (10.5)	Check solar flux instrument Orient Orbiter Orient SIPS Take data Shut down	TBD	TBD	TBD	TBD	TBD	TBD

A3. PAYLOAD CONFIGURATION

The Flight 2 Payload shall be configured in accordance with the following sections.

- A3.1 PAYLOAD MANIFEST AND PHYSICAL PROPERTIES. See Table AIII.I-1 for the Flight 2 manifest and physical properties. On Table AIII.I-2, the mass properties are summarized. The center of gravity estimates are covered on Figure A3.1-1.

Table AIII.I-1. AMPS Flight 2 Payload Manifest

Table AIII.I-1. AMPS Flight 2 Payload Manifest														
EQUIPMENT LOCATION <u>Orbiter Aft Flight Deck</u>											CENTER OF GRAVITY			
APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	X	Y	Z
(To be supplied) ↓	1	Keyboard assembly			X						5	(To be supplied) ↓		
	1	Data display unit			X						30			
	1	High rate digital recorder			X						47			
	1	C&W and safing panel	X											
	1	Documentation camera	X											
	1	Safing cmd J-Box	X											
	1	C&W J-box	X											
	1	C&W signal cable	X											
	1	Safing signal cable	X											
	1	C&W signal cable	X											
	1	Safing signal cable	X											
	1	C&W and safing power cable	X											
		Subtotals												

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

EQUIPMENT LOCATION <u>Spacelab Module</u>												CENTER OF GRAVITY		
APPLICABLE SERIAL NUMBER	QUANTITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION SUPPORT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	X	Y	Z
(To be supplied) ↓	2	Single rack			X						78	(To be supplied) ↓		
	2	Double rack			X						124			
	4	Experiment switch panel			X						16			
	1	Experiment computer			X						33			
	1	Experiment I/O unit			X						33			
	5	Experiment RAU			X						49			
	2	Keyboard assembly			X						10			
	2	Data display unit			X						60			
	1	High rate multiplexer			X						25			
	4	Stowage container ceiling			X						29			
	4	Rails console vertical			X						5			
	3	Rack foot restraint			X						3			
	1	Intercom remote station			X						1			
	1	Voice digitizer			X						1			
	1	SIPS control panel	X											

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)														
EQUIPMENT LOCATION <u>Spacelab Module (Continued)</u>			INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	CENTER OF GRAVITY		
APPLICABLE SERIAL NUMBER	QUAN-TITY	NAME OR DESCRIPTION										X	Y	Z
(To be supplied ↓	1	QBIPS control panel	X									(To be supplied ↓		
	1	Lidar control panel, Type 1	X											
	1	Lidar control panel, Type 2	X											
	1	RF sounder control panel	X											
	1	Magnetometer mast control panel		X										
	1	Support mast control panel		X										
	1	Support mast control cable		X										
	1	Video and display recorder	X											
	1	Payload C&W panel		X										
	1	C&W J-box		X										
	1	Safing command J-box		X										
	1	Quartz crystal microbalance controller		X										
	1	Lidar control cable		X										
	1	OBIPS control cable		X										
	1	SIPS control cable		X										

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

EQUIPMENT LOCATION Spacelab Module (Continued)

[illegible]

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)														
EQUIPMENT LOCATION <u>Inter-Pallet/Module</u>											CENTER OF GRAVITY			
APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	X	Y	Z
(To be supplied) ↓	3	Safing command signal cable	X								(To be supplied) ↓			
	3	C&W signal cable	X											
	1	RF sounder signal cable	X											
	4	QCM signal cable	X											
	1	Lidar control cable	X											
	1	OBIPS control cable	X											
	1	SIPS control cable	X											
	3	Standard coax cable	X											
		Subtotal												

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

EQUIPMENT LOCATION Pallet No. 1

APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	CENTER OF GRAVITY		
												X	Y	Z
(To be supplied)	1	Experiment inverter 400 Hz			X						(To be supplied)			
	1	ESP functional assembly (ESP Type 1)		X										
	1	RF sounder	X											
	1	Test body	X											
	1	EPDB - experiment			X									
	1	RAU - experiment			X									
	1	C&W J-box		X										
	1	Labcraft emergency safing unit		X										
	1	SIPS control cable		X										
	1	OBIPS control cable		X										
	1	Lidar control cable		X										
	1	Barium release functional assembly		X										
	1	HRM coax cable		X										
	1	C&W cable		X										
	1	Support mast		X										

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)														
EQUIPMENT LOCATION <u>Pallet No. 1 (Continued)</u>														
APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	CENTER OF GRAVITY		
												X	Y	Z
(To be supplied)	1	C&W cable, transit	X								(To be supplied)			
↓	2	Safing command cable	X											
	1	Safing command cable	X											
	1	HRM coax cable, transit	X											
	3	Standard power cable	X											
	3	Standard C&W cable	X											
	4	Type 1 standard RAU cable	X											
	2	Type 2 standard RAU cable	X											
	200	Standard cable clamp, pallet	X											
	1	Thermal blanket set, RF sounder	X											
	1	Thermal blanket set, ESP functional assembly	X											
1	Thermal blanket set, test body	X												
1	Thermal blanket set, EPDB			X										

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)														
EQUIPMENT LOCATION Pallet No. 1 (Continued)											CENTER OF GRAVITY			
APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD SUPPORT EQUIPMENT	SPACELAB MISSION DEPENDENT EQUIPMENT	MULTI-MISSION SUPPORT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	X	Y	Z
(To be supplied) ↓	1	Thermal blanket set, RAU			X						(To be supplied)			
	1	Thermal blanket set, C&W J-box	X											
	1	Thermal blanket set, L/C emergency safing unit	X											
	1	Thermal blanket set, pallet cable tray			X									
	1	Thermal blanket set, pallet surface No. 1			X									
	1	Thermal blanket set, pallet surface No. 2	X											
	1	Thermal blanket set, pallet surface No. 3	X											
	1	Thermal blanket set, pallet surface No. 4	X											
	1	Thermal blanket set, pallet surface No. 5	X											
	1	Thermal blanket set, pallet surface No. 6	X											

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)														
EQUIPMENT LOCATION Pallet No. 1 (Continued)			INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	CENTER OF GRAVITY		
APPLICABLE SERIAL NUMBER	QUAN-TITY	NAME OR DESCRIPTION										X	Y	Z
(To be supplied) ↓		Thermal blanket clamps	X								(To be supplied)			
	2	Cold plate				X								
		Cold plate, standoff				X								
	1	Freon line system				X								
		Pallet hardpoints				X								
	1	Thermal blanket set, Barium release functional assembly	X											
	1	EPDB (experiment) mounting hardware set			X									
	1	RAU (experiment) mounting hardware set	X											

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)														
EQUIPMENT LOCATION Pallet No. 1 (Continued)														
APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	CENTER OF GRAVITY		
												X	Y	Z
(To be supplied) ↓	1	C&W J-box mounting hardware set		X							(To be supplied)			
	1	Labcraft emergency safing unit mounting hardware set		X								↓		
		Subtotal												

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

EQUIPMENT LOCATION <u>Pallet No. 2</u>											CENTER OF GRAVITY			
APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD SUPPORT EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	X	Y	Z
		(To be supplied) <												

Table A.III.I-1. AMPS Flight 2 Payload Manifest (Continued)

EQUIPMENT LOCATION Pallet No. 3

APPLICABLE SERIAL NUMBER	QUAN- TITY	NAME OR DESCRIPTION	INSTRUMENT	LABCRAFT EQUIPMENT	COMMON PAYLOAD EQUIPMENT	SPACELAB MISSION SUPPORT EQUIPMENT	MULTI-MISSION DEPENDENT EQUIPMENT	FLIGHT SOFTWARE	FLIGHT DATA FILE	MISCELLANEOUS	MASS KG	CENTER OF GRAVITY		
												X	Y	Z
		(To be supplied) ↓												
		Subtotal												

Table AIII.I-2. Mass Properties Summary

	Launch Mass (kg)	Landing Mass (kg)
Pallet segment No. 1	1,153	638
Pallet segment No. 2	1,511	1,422
Pallet segment No. 3	1,049	879
Module	240	240
Aft flight deck	80	80
Total payload mass	4,033	3,259
Mission-dependent equipment	697	697
Baseline Spacelab equipment	7,562	7,162
Payload specialist	210	210
Total payload mass	12,502	11,328

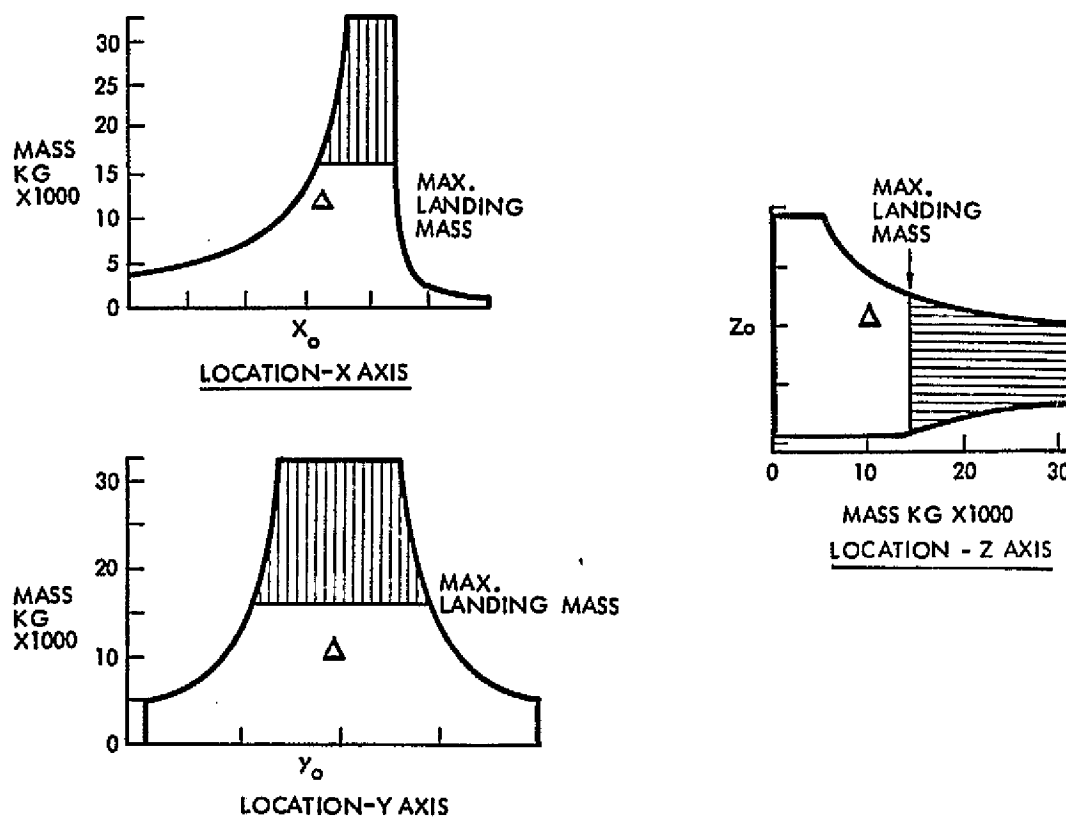


Figure A3.1-1. Flight 2 Center of Gravity Estimates

A3.2 PAYLOAD LAYOUTS. The AMPS Flight 2 Payload layouts are given on the following figures:

Figure A3.2-1. OAFD Payload Layout (TBS)

Figure A3.2-2. Spacelab Module Controls and Displays Layout

Figure A3.2-3. Pallet Layout

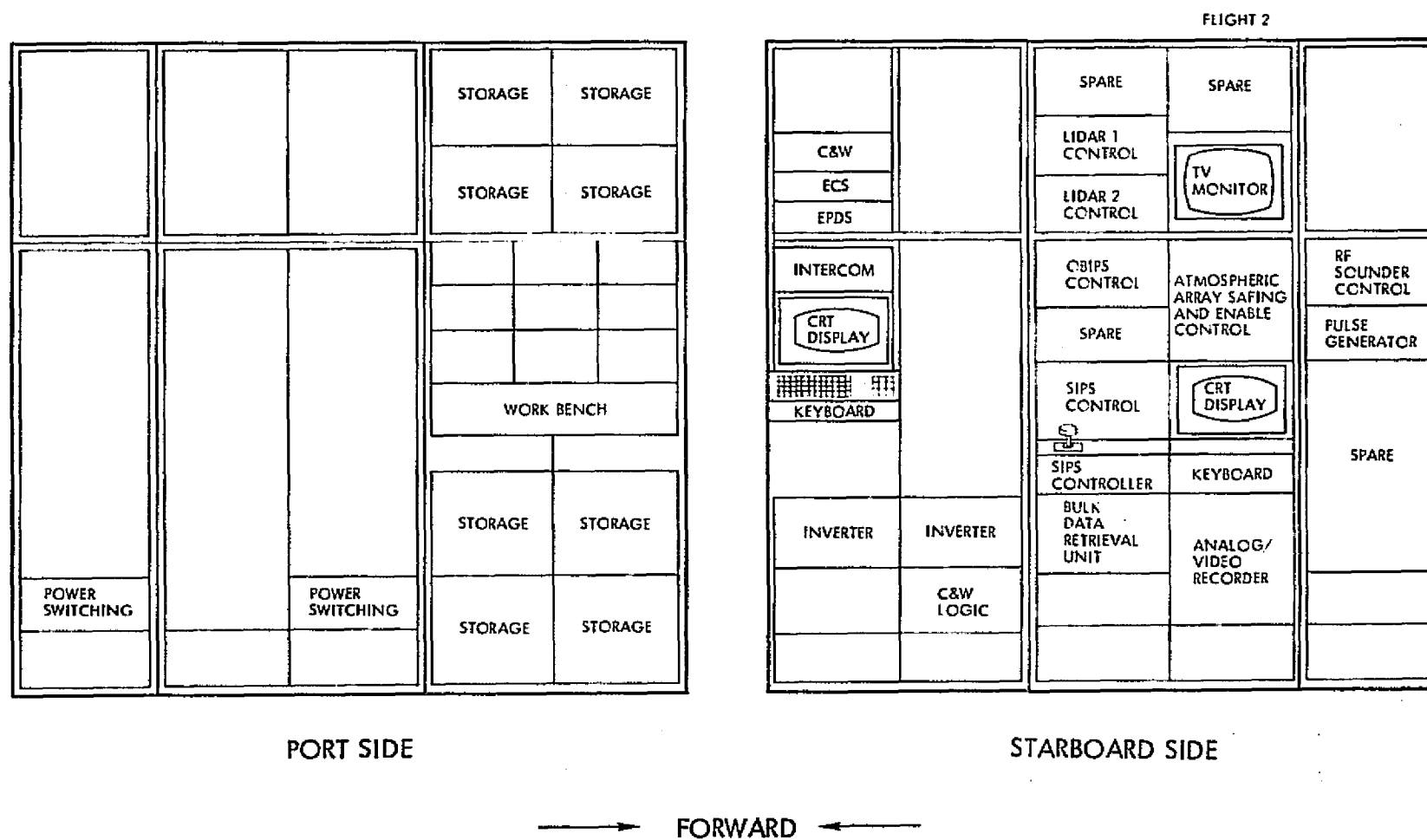


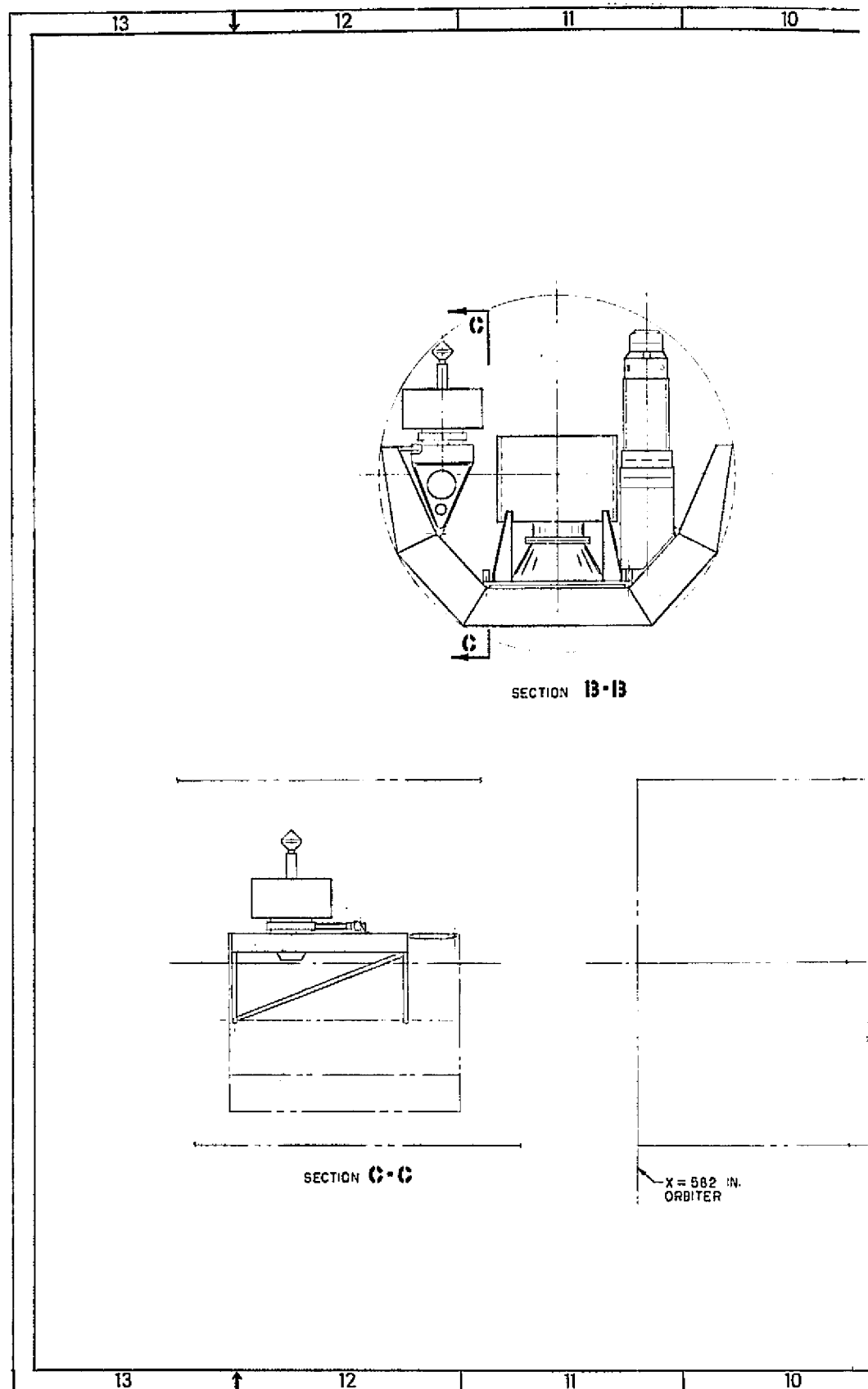
Figure A3.2-2. Spacelab Module Controls and Displays Layout

A3.3 INSTRUMENT DESCRIPTIONS. This section contains a description of the Flight 2 instruments and other experiment apparatus. It includes pallet-mounted equipment, boom-mounted equipment, and equipment contained within the Environmental Sensing Packages (ESP). The following instruments are required for AMPS Flight 2:

- (1) Lidar
- (2) ESP electric and magnetic receivers
- (3) ESP DC electric field meter
- (4) ESP medium energy electron detector
- (5) ESP ion mass and distribution analyzer
- (6) Optical band imaging system (OBIPS)
- (7) Infrared interferometer cryogenic limb scanner
- (8) Quartz crystal microbalance
- (9) Vector magnetometer
- (10) ESP magnetometer
- (11) Solar flux monitor
- (12) ESP Langmuir probe
- (13) ESP neutral mass spectrometer
- (14) RF sounder transmitter
- (15) ESP mounted receiver
- (16) UV-VIS-IR spectrophotometers
- (17) Deployable test body

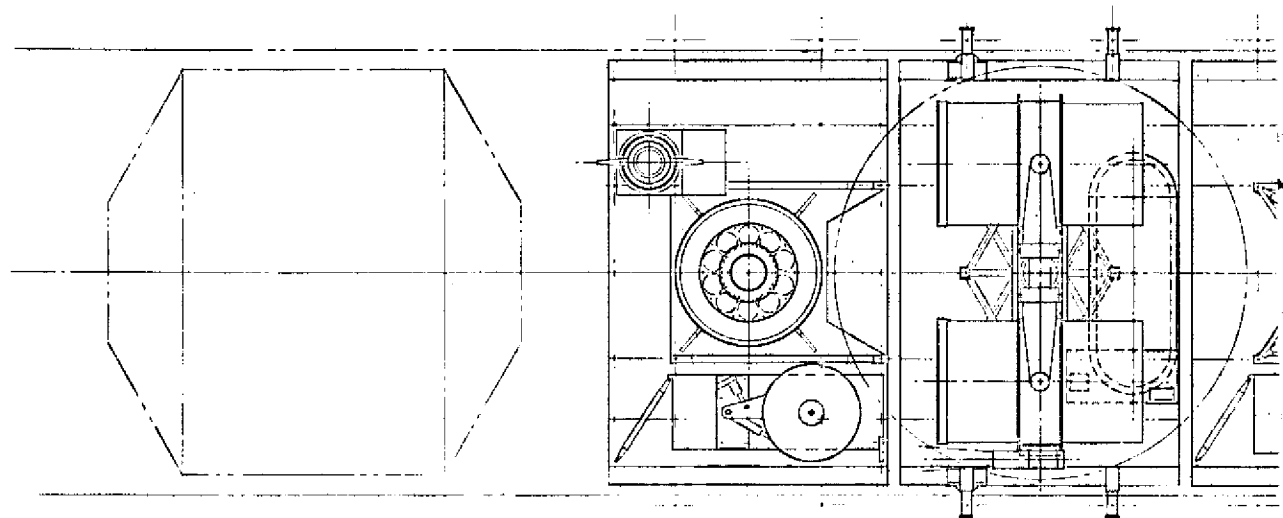
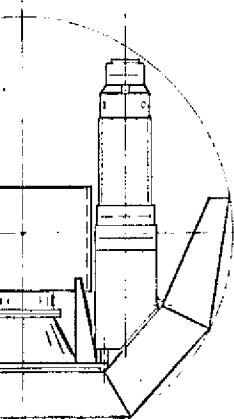
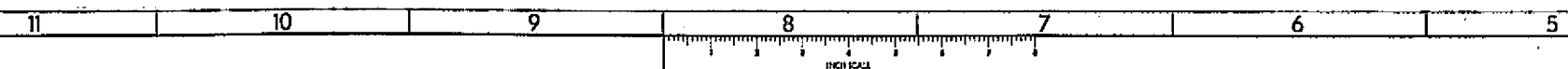
Items (1) through (13) have been described in Section 3.1.

The following sections describe items (14) through (17).

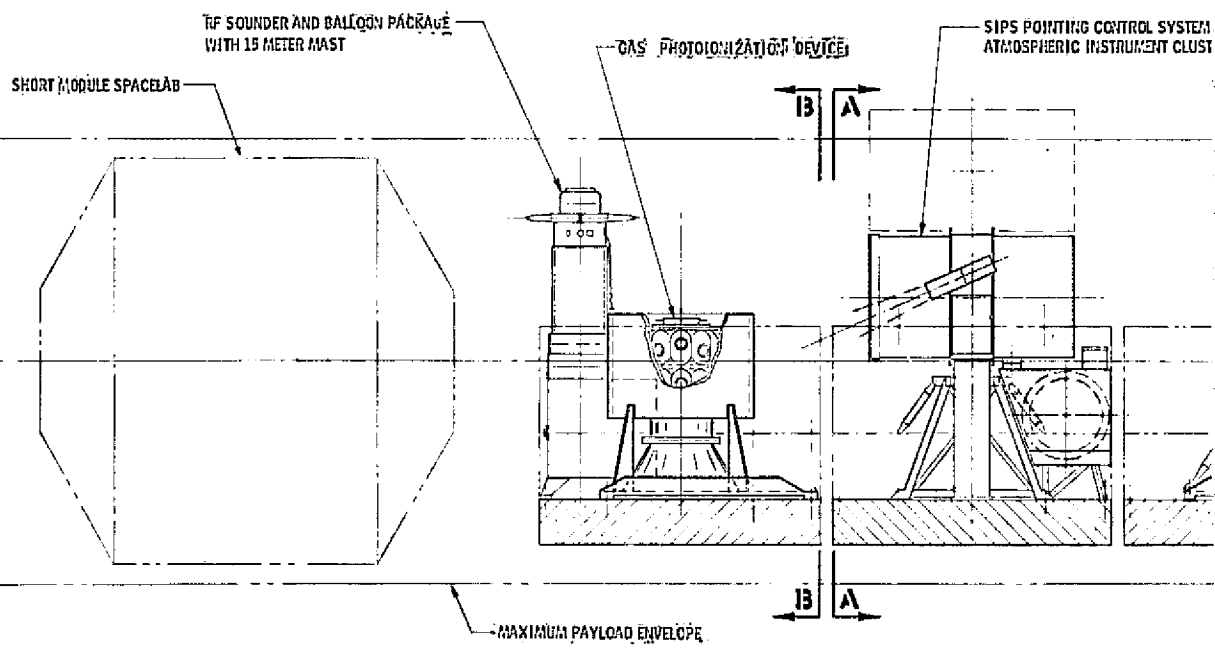


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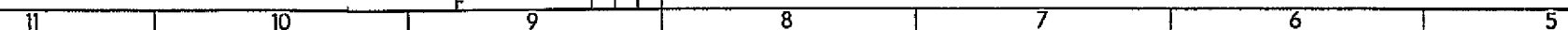
TION 13-13



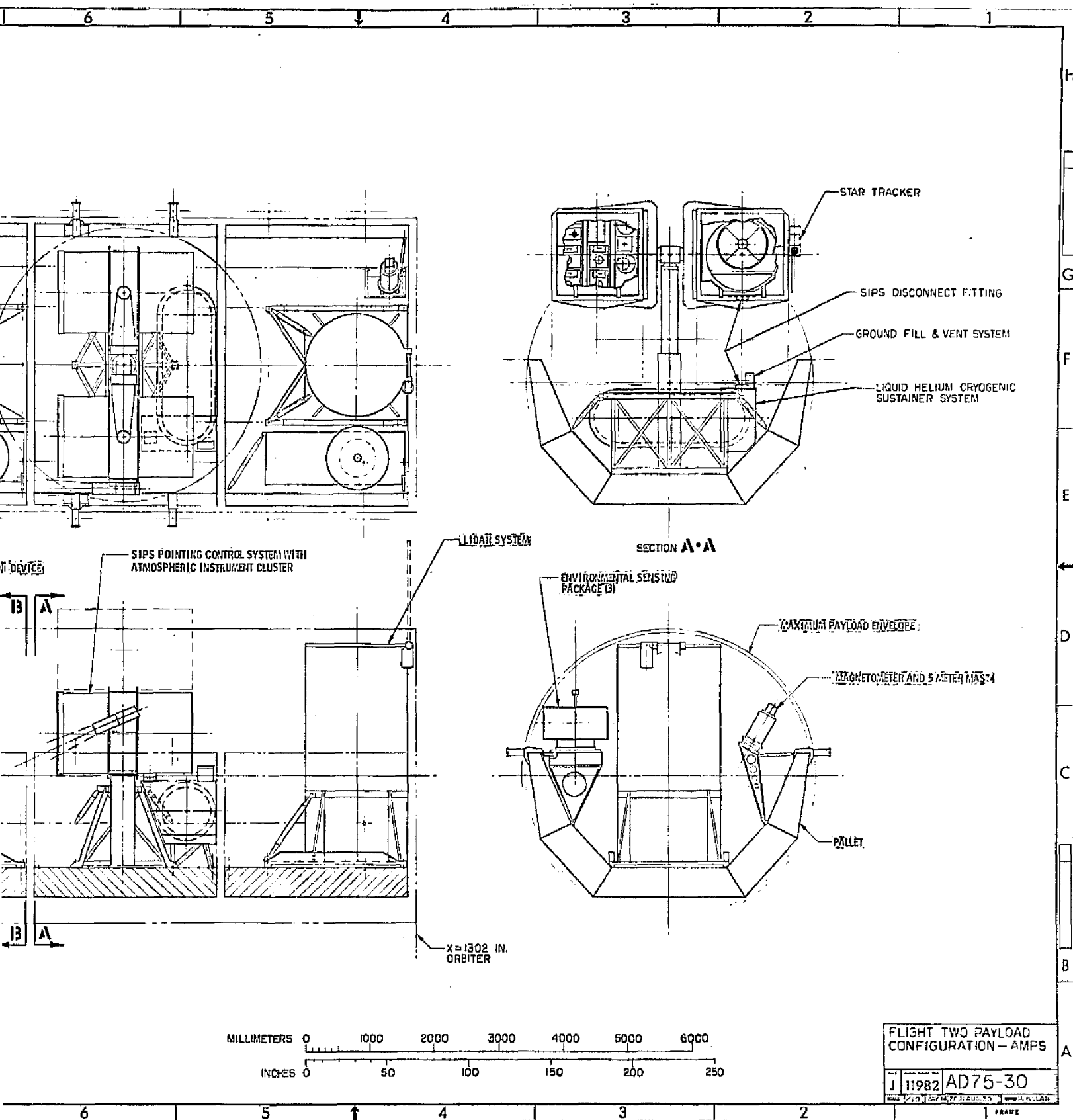
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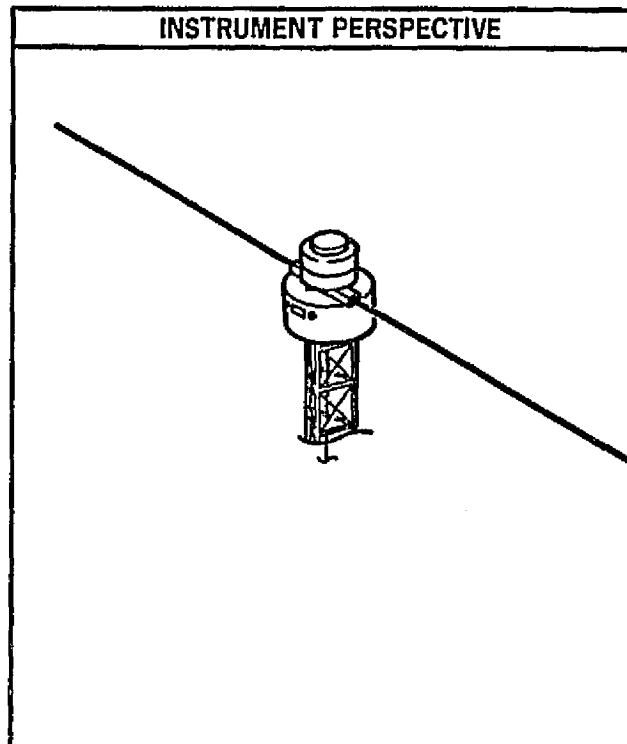
FOLDOUT FRAME 2



FOLDOUT FRAME 3

Figure A3.2-3. Pallet Layout - Flight 2

- A3.3.1 RF sounder transmitter. The RF sounder consists of a transmitter capable of covering the frequency range from 20 kilohertz to 20 megahertz at a continuous wave power of 0 to 100 watts or a pulsed power up to a maximum of 10 kW, and a dipole transmitting antenna of variable length up to 100 meters tip-to-tip. The transmitting antenna must be mounted about 15 meters from the nearest conducting surface to minimize ground plane interference.



MASS PROPERTIES			
LAUNCH WT.	=	218	KG
LANDING WT.	=	218	KG
I_x	=	TBD	N·M
I_y	=	TBD	N·M
I_z	=	TBD	N·M

ELECTRICAL POWER			
TYPE			
STANDBY			WATTS
OPERATING	TBD		WATTS
TOTAL ENERGY	TBD		KWH

THERMAL CHARACTERISTICS			
MAX. EXT. TEMP.			°K
POWER DISSIPATION			
CONDUCTED			WATTS
RADIATED			WATTS
TOTAL			WATTS

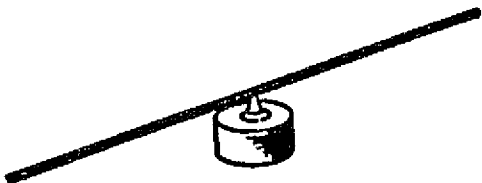
EQUIPMENT HAZARDS

WIRING SCHEMATIC

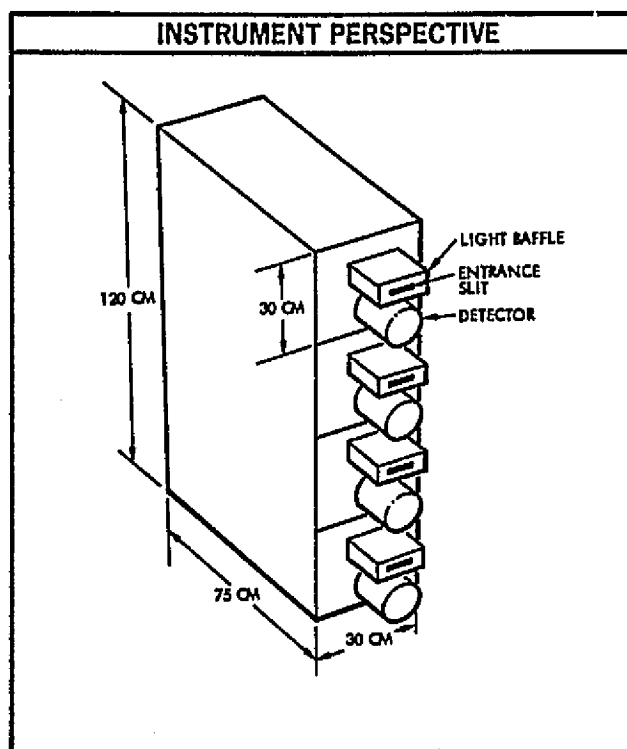
OPERATING CHARACTERISTICS	
CONTROL	(MANUAL OR AUTOMATIC)
DUTY CYCLE	
DATA RATE	KBPS
OPERATING TIME	TOTAL
CREW TASKS	
FIELD OF VIEW	
MODES	
COMMANDS	

- OPERATING SEQUENCE DESCRIPTION
- SPECIAL SUPPORT REQUIREMENTS
- CALIBRATION REQUIREMENTS:
 - PRE-LAUNCH
 - FLIGHT
 - POST-FLIGHT

- A3.3.2 ESP mounted receiver. The ESP mounted receiver is capable of covering the frequency range from 100 kilohertz to 20 megahertz. The receiver has 20 selectable bandpass channels and is equipped with a dipole electric field antenna and a search coil magnetic field antenna.

INSTRUMENT PERSPECTIVE	MASS PROPERTIES
	LAUNCH WT. = <u>TBD</u> KG LANDING WT. = <u>TBD</u> KG $I_x = \frac{\text{TBD}}{\text{N}\cdot\text{M}}$ $I_y = \frac{\text{TBD}}{\text{N}\cdot\text{M}}$ $I_z = \frac{\text{TBD}}{\text{N}\cdot\text{M}}$
	ELECTRICAL POWER TYPE _____ STANDBY _____ WATTS OPERATING <u>TBD</u> WATTS TOTAL ENERGY <u>TBD</u> KWH
	THERMAL CHARACTERISTICS MAX. EXT. TEMP. _____ °K POWER DISSIPATION CONDUCTED _____ WATTS RADIATED _____ WATTS TOTAL _____ WATTS
	OPERATING CHARACTERISTICS CONTROL (MANUAL OR AUTOMATIC) _____ DUTY CYCLE _____ DATA RATE _____ KBPS OPERATING TIME _____ TOTAL CREW TASKS _____ FIELD OF VIEW _____ MODES _____ COMMANDS _____
EQUIPMENT HAZARDS	• OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT
WIRING SCHEMATIC	

- A3.3.3 Ultraviolet, visible, infrared spectrophotometers. These photometers are either fixed wavelength or scanning spectrometers with variable wavelength resolutions over the full optical spectrum depending upon the type of detector used. They are general purpose low light level detectors which may have telescopes attached if necessary. There will be a four detector group of photometers.



MASS PROPERTIES		
LAUNCH WT. =	65	KG
LANDING WT. =	65	KG
$I_x =$	TBD	N·M
$I_y =$	TBD	N·M
$I_z =$	TBD	N·M

ELECTRICAL POWER		
TYPE		
STANDBY		WATTS
OPERATING		WATTS
TOTAL ENERGY		KWH

THERMAL CHARACTERISTICS		
MAX. EXT. TEMP.		°K
POWER DISSIPATION		
CONDUCTED		WATTS
RADIATED		WATTS
TOTAL		WATTS

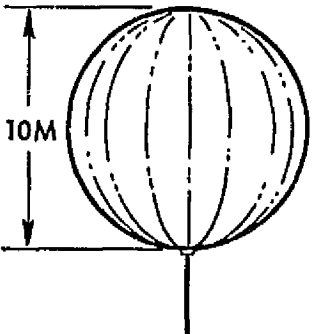
EQUIPMENT HAZARDS

WIRING SCHEMATIC

OPERATING CHARACTERISTICS
CONTROL (MANUAL OR AUTOMATIC)
DUTY CYCLE
DATA RATE
OPERATING TIME
CREW TASKS
FIELD OF VIEW
MODES
COMMANDS

- OPERATING SEQUENCE DESCRIPTION
- SPECIAL SUPPORT REQUIREMENTS
- CALIBRATION REQUIREMENTS:
 - PRE-LAUNCH
 - FLIGHT
 - POST-FLIGHT

A3.3.4 Deployable test body. The deployable test body consists of a conducting surface balloon that is inflated at the top of the 15-meter mast.

INSTRUMENT PERSPECTIVE 	MASS PROPERTIES LAUNCH WT. = <u>20</u> KG LANDING WT. = <u>0</u> KG $I_x = \frac{\text{TBD}}{\text{N}\cdot\text{M}}$ $I_y = \frac{\text{TBD}}{\text{N}\cdot\text{M}}$ $I_z = \frac{\text{TBD}}{\text{N}\cdot\text{M}}$
EQUIPMENT HAZARDS	ELECTRICAL POWER TYPE _____ STANDBY _____ WATTS OPERATING <u>TBD</u> WATTS TOTAL ENERGY _____ KWH
WIRING SCHEMATIC	THERMAL CHARACTERISTICS MAX. EXT. TEMP. _____ °K POWER DISSIPATION CONDUCTED _____ WATTS RADIATED _____ WATTS TOTAL _____ WATTS
	OPERATING CHARACTERISTICS CONTROL <u>(MANUAL OR AUTOMATIC)</u> DUTY CYCLE _____ DATA RATE _____ KBPS OPERATING TIME _____ TOTAL CREW TASKS _____ FIELD OF VIEW _____ MODES _____ COMMANDS _____ • OPERATING SEQUENCE DESCRIPTION • SPECIAL SUPPORT REQUIREMENTS • CALIBRATION REQUIREMENTS: • PRE-LAUNCH • FLIGHT • POST-FLIGHT

A3.4 LABCRAFT SUPPORT EQUIPMENT. This section describes the inventory of Labcraft support equipment required to support the Flight 2 mission. It includes the following items:

- (1) Environmental sensor package (ESP)
- (2) SIPS internal support structure
- (3) Cryogenic canister
- (4) Barium release
- (5) Controls and displays
- (6) Magnetometer mast
- (7) Support mast.

Items (1), (4), and (7) are different from Flight 1.

A3.4.1(a) Environmental sensor package (type 1). The principle function of the ESP-1 to be used on Flight 2 is to position a set of passive instruments remote from the Orbiter (TBD to TBD km) to measure the space environment. The ESP will be deployed from the Orbiter via the remote manipulator system (RMS). It will operate attached to the Orbiter and will provide necessary support functions (i.e., power, communication, data processing) to the instrument payload. Communications will be established with the Orbiter via the payload interrogator link. The ESP-1 will be retracted by the Orbiter RMS and will be returned to the ground for reuse. The ESP-1 must be mounted on a pallet so as to allow free access for the RMS to permit safe deployment and retrieval. Other features of the ESP are shown in Figure A3.4.1-1. The ESP-1 will carry the following complement of instruments:

- (1) Electric and magnetic receivers
- (2) DC electric field meter
- (3) Medium energy electron detector
- (4) Ion mass and distribution analyzer
- (5) Vector magnetometer
- (6) Langmuir probe
- (7) Neutral mass spectrometer.

(b) Environmental sensor package (type 2). The ESP-2 is the same basic carrier with the RMS fitting removed. ESP-2 will be deployed from the Orbiter in free flight and therefore is mounted on a spring ejection device. The ESP-2 will carry the same instruments as ESP-1 and the ESP mounted antenna.

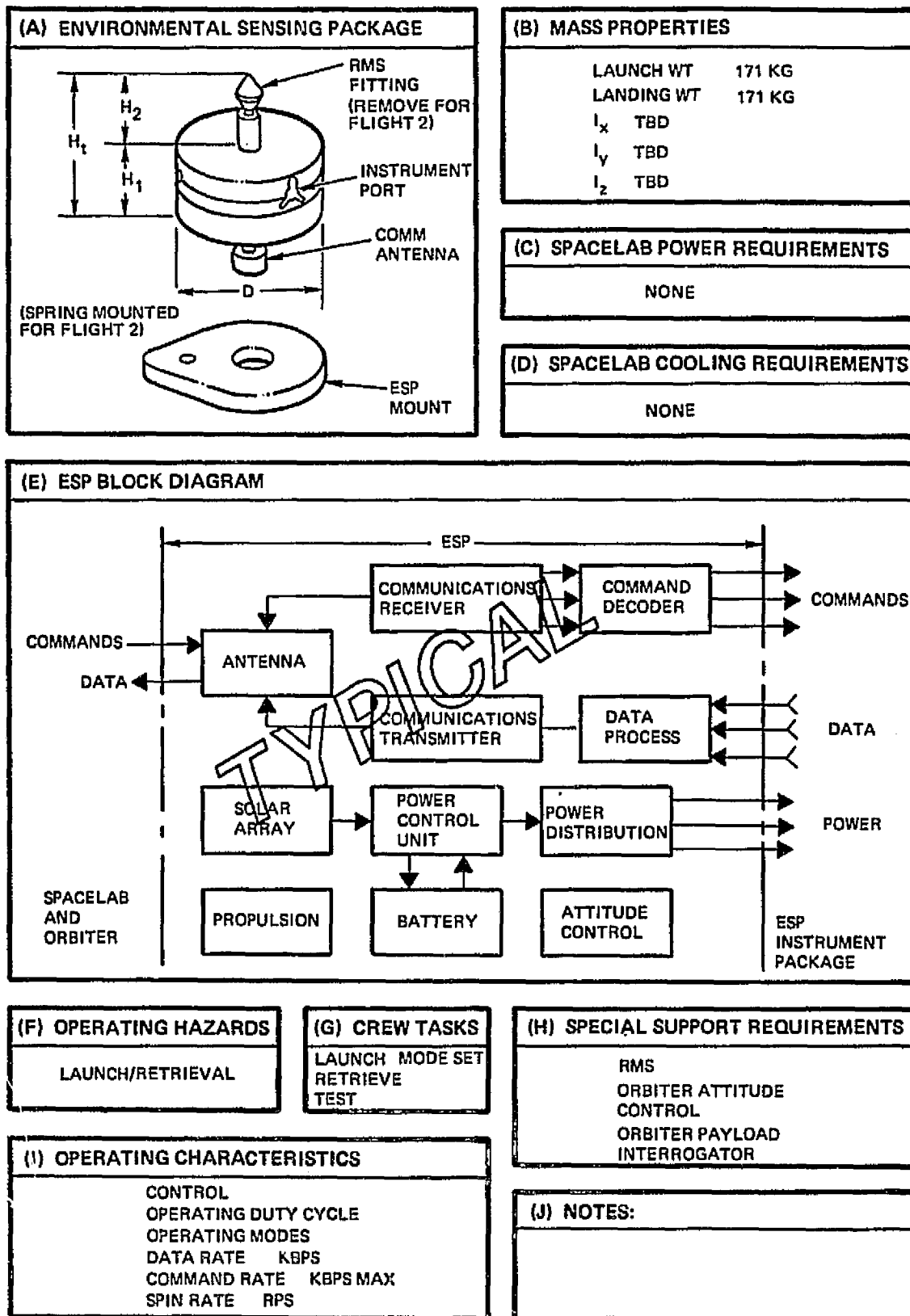
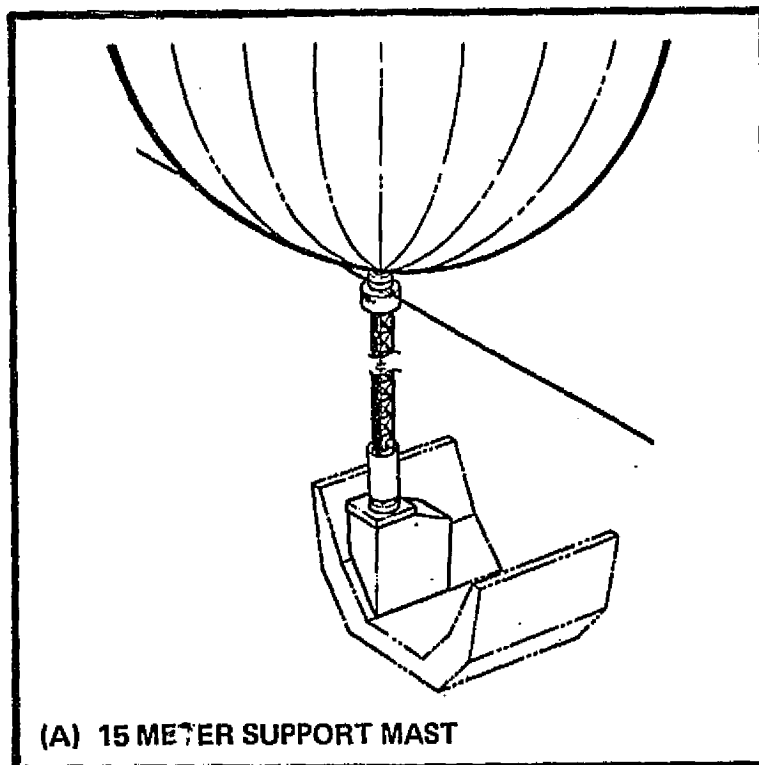


Figure A3.4.1-1. Environmental Sensor Package

I



A3.4.3 Support mast. The support mast is used to place the test body and RF sounder outside the magnetic environment of the Orbiter. In operation, it will deploy, position, and point the instruments to the desired orientation in accordance with the preselected installation/alignment. The mast system will include a cable to provide power and signal wiring between Spacelab and the mast-mounted magnetometer. When the experiment work is completed, the mast will be retracted into the cargo bay and stowed for landing. Figure A3.4.3-1 shows the details of the mast.



(B) MAST CHARACTERISTICS

WEIGHT 45 KG

ORIENTATION CONTROL

ANGLE TBD

LENGTH 0 TO 15 M

TIP LOAD CAPABILITY TBD KG

LOCATION:

X = TBD Y = TBD Z = TBD

Figure A3.4.3-1. Support Mast

A3.5 COMMON PAYLOAD SUPPORT EQUIPMENT (CPSE). The following items of Spacelab CPSE have been identified as required to support Flight 2:

(none)

A3.6 SPACELAB MISSION DEPENDENT EQUIPMENT (MDE). The Labcraft Flight 2 configuration includes certain Spacelab mission dependent equipment as noted in Table AIII.VI-1.

Table AIII.VI-1. Spacelab Mission Dependent Equipment

Equipment Description	Unit Weight (kg)	Quantity	Total Weight (kg)
Single Rack	36.1	2	72.2
Double Rack	57.3	2	114.6
Pallet Hardpoints	1	33	33
Cold Plate	6.3	2	13
Cold Plate Standoff	0.9	12	11
Thermal Capacitor	12.5	0	0
Freon Line System	TBD	TBD	TBD
Pallet Thermal Cover	19.8	3	59.4
Experiment Switch Panel	3.7	1	3.7
Power Harness	TBD	TBD	TBD
Experiment Computer	30.4	1	30.4
Experiment I/O Unit	29.5	1	29.5
Experiment RAU	8.9	10	89
Keyboard	4.5	3	13.50
CRT Display	24.25	3	72.75
High Bit Rate Recorder	43	1	43
High Rate Multiplexer	11	1	11

A3.7 MULTI-MISSION SUPPORT EQUIPMENT (MMSE). The Flight 2 payload contains the same MMSE as Flight 1.

A3.8 SOFTWARE CONFIGURATION. The following flight software packages that will be on the certified flight tape, control number (TBD), are required to support this mission. These packages will be used in the CDMS experiment flight computer. All packages are written on the mass memory unit tape. The number of copies of each package written on the tape is (TBD). All permanently resident packages are loaded in the experiment computer at liftoff, as are the application packages supporting the first operations planned after the orbit phase has started. The following flight software packages are delivered by ESA and are required for Flight 2:

- | | |
|--|-----------------------------|
| (1) Experiment computer operating system | (Resident) |
| (2) Checkout language interpreter | (Resident if space permits) |
| (3) Keyboard interpreter | (Resident if space permits) |
| (4) Experiment CDMS checkout and fault isolation | (Non-resident) |
| (5) In-flight monitor | (Resident) |

The following are Labcraft flight software packages for Flight 2:

(a) Labcraft coordination package

Labcraft system management	(Resident)
----------------------------	------------

(b) AMPS instrument and flight support equipment management packages

Barium release	(Non-resident)
RF sounder control	
Vector magnetometer	
Cryo infrared limb scanner radiometer	
Cryo interferometer spectrometer	
Quartz crystal microbalance	
Lidar	
OBIPS	
Solar flux monitor	
SIPS control	
Mast controls	
Electrostatic analyzer	
Medium energy electron detector	
DC electric field meter	
E and B receivers	
Langmuir probe	
ESP telemetry stream processor	(Non-resident)

(c) AMPS experiment management packages

Each package may consist of several subpackages which can be independently called. However, it is expected that the solar radiation package will consist of a single package that will be called as a unit.

Low altitude conductivity modification	(Non-resident)
High frequency wave interactions	
Long delay echoes	
Plasma flow	
Minor constituents	
D-region composition changes	
Oxygen variations	
Neutral composition	
Ozone changes at high altitude	
Solar flux calibration	(Non-resident)

(d) On-board test packages

There will be one on-board test package for each instrument and flight support equipment carried for Labcraft that requires test prior to, during, or after experiment use. On-board test packages will be independently called for by the flight operator. They are all non-resident.

A3.9 FLIGHT DATA FILE (FDF). The FDF required to support the AMPS is composed of the Spacelab flight dependent FDF and the unique AMPS FDF. The FDF requirement is shown in Table AIII.IX-1.

Table AIII.IX-1. AMPS Flight Data File

STS Flight Dependent	AMPS
Spacelab systems check lists (C/L)	Experiment C/L
Spacelab software C/L	Log books
Spacelab activation C/L	Payload schematics
Spacelab deactivation C/L	Payload malfunction procedures
Spacelab schematics	Payload flight plan
Spacelab malfunction procedures	Experiment reference data
Cue cards	Cue cards
Module subsystem operations	Experiment operations
Pallet subsystem operations	NIM/CAMAC operations
Deployment/retrieval C/L	Note books
	Scratch pads

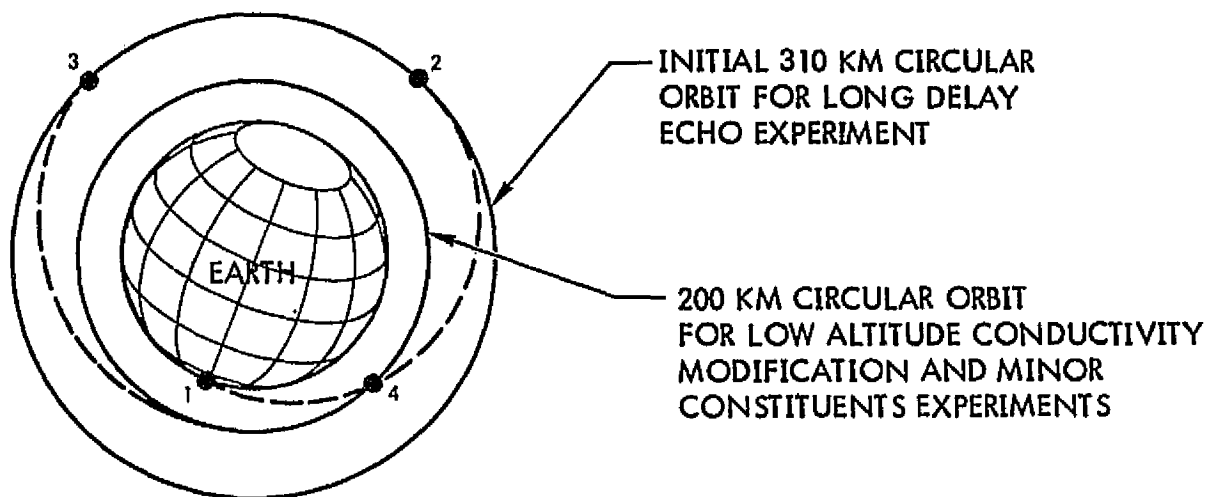
A3.10 MISCELLANEOUS EQUIPMENT. This section identifies any equipment, tool, or supporting data required by AMPS which is not included in one of the standard categories previously discussed. The miscellaneous equipment is (TBD).

A4 PAYLOAD FLIGHT REQUIREMENTS

A4.1 FLIGHT PLAN

A4.1.1 Orbit characteristics.

A4.1.1.1 The mission profile for Flight 2, illustrated in Figure A4.1.1-1, begins with a northeasterly launch from ETR into a 115 by 310 km orbit inclined at 57 degrees. As shown in the figure, the OMS adds 57 m/sec tangentially at first apogee to circularize the orbit at 310 km. The Orbiter remains in this orbit for about 53 hours, performing both the long delayed echos and a part of the D-region composition experiments. At approximately 53 hr 45 min after liftoff, a 32 m/sec OMS retro ΔV initiates a Hohmann transfer down to 200 km. Forty-five minutes later, a second retro ΔV of 33 m/sec circularizes the orbit at 200 km for the low altitude conductivity plasma flow, minor constituents, D-region changes and oxygen variation experiments.



EVENT	TIME HR: MIN	ΔV MPS	ORBITAL CHARACTERISTICS (KM)		INCLINATION (DEG)
			hp	ha	
1 ET SEPARATION THRU INSERTION	0:11	70	115	310	57
2 CIRCULARIZATION	0:43	57	310	310	57
3 TRANSFER	53:45	32	200	310	57
4 CIRCULARIZATION	54:30	33	200	200	57
5 DEORBIT	166:00	85	-	-	-

Figure A4.1.1-1. An Orbit Sequence Has Been Chosen Which Meets All Scientific Objectives

A4.1.1.2 Atmospheric drag effects will require correction by periodic RCS period trim maneuvers totaling less than 1 m/sec while in the 310 km orbit, and 50 m/sec while in the 200 km orbit. This appears to be well within the Orbiter's RCS ΔV capability.

A4.1.1.3 The requirement for Fort Churchill flyover at twilight drives the selection of launch time. Two daily launch windows are available. The first occurs during the early afternoon resulting in Fort Churchill flyover at dusk twilight. The second window occurs shortly before midnight and results in a dawn twilight flyover.

A4.1.1.4 Fort Churchill flyover at the dark limit of the dawn twilight region is preferred because the orbit plane regression motion will cause the flyover local times in the northern hemisphere to become progressively later as the mission continues, thereby improving darkness conditions for the other experiments. Conducting this mission at or near the winter solstice will provide the best darkness conditions at high northern latitudes.

A4.1.2 Flight timeline. The experiment operations and scientific flight crew timeline is shown in Figure A4.1.2-1. Each of the experiments is performed independently of the others with the exception of the atmospheric experiments. These activities are conducted using some common equipment. They have been scheduled as targets of opportunity. Payload Specialist No. 1 is prime for these experiments and is supported by the Mission Specialist. Payload Specialist No. 2 is prime for the ozone density and minor constituents experiments. However, each PS is required to be proficient in each experiment.

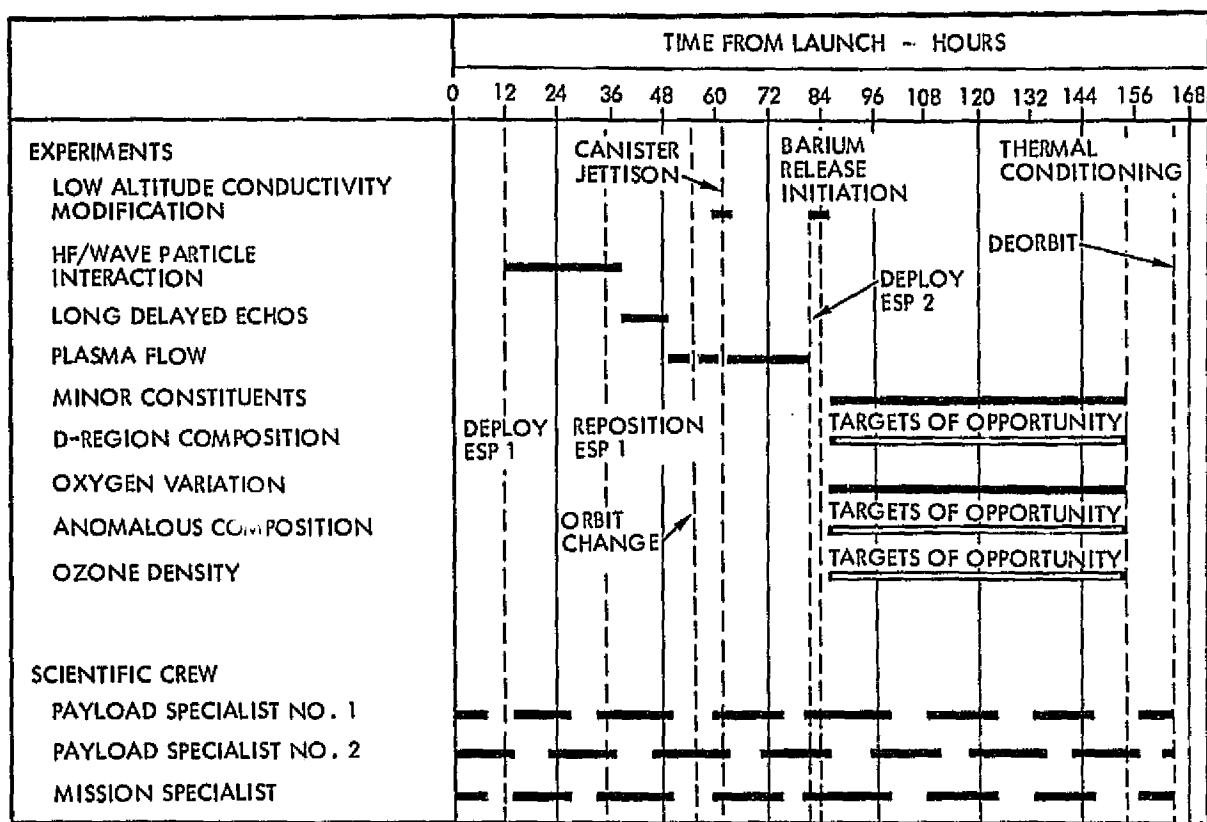


Figure A4.1.2-1. Experiment Operations and Scientific Flight Crew Timeline

A4.2 SPACELAB/ORBITER RESOURCE REQUIREMENTS

A4.2.1 Electrical power. The electrical power and distribution subsystem for Shuttle payload missions do not require the design of an electrical power source because power is provided from a dedicated power source in the Orbiter through the Spacelab power distribution system. No changes are required to the existing system. A review of the electrical power and energy requirements for Flight 2 resulted in power and energy values within the capabilities provided. A comparison of the capabilities and requirements are shown in Table AIV.II.I-1.

Table AIV.II.I-1. AMPS Flight 2 Electrical Power and Energy Requirement

	Capability	Requirement Flight 2
Sustaining (kW)	3.4	3.2
Peak (kW)	7.4 15 min, max/3 hr	3.5 10 min/10-15 hr
Energy (kWh)	369	261

The sustaining power available for the short module and three pallet segment Spacelab configuration as reported in the Spacelab System PDR-A is 3.4 kW with a peak of 7.4 kW. The total energy available is 369 kWh. The sustaining power requirement for Flight 2 in Table AIV.II.I-1 is maximum sustaining power but not required over the total mission. A large margin of energy is available. A detailed review was done of the specific AMPS Flight 2 timeline and instrument power requirements, and the resulting power and energy requirements profile are shown in Figure 4.2.1-1.

A4.2.2 Thermal control. The thermal control approach for Flight 2 is identical to that of Flight 1.

A4.2.2.1 Standby heater requirements. The standby heater requirements are virtually the same as for Flight 1 with the substitution of the barium thermite gas release system for the electron accelerator.

A4.2.2.2 Active cooling requirements. The heat dissipated into the active Spacelab cooling loops was determined from the thermal analysis and is shown in Table AIV.II.II-1.

A4.2.2.3 Cryogenic instrument accommodation. No change from Flight 1.

Table AIV.II.II-1. Heat Dissipated Into the Active Cooling Loop

Instrument/Assembly	Peak Cold Plate/Heat Exchanger Requirements (W)	Orbiter Cooling Capacity (W)
Pallet Lidar	1,991	2,000 (2 plates)
Module Avonics HX	159	4,510
Maximum	2,150	5,200 Total

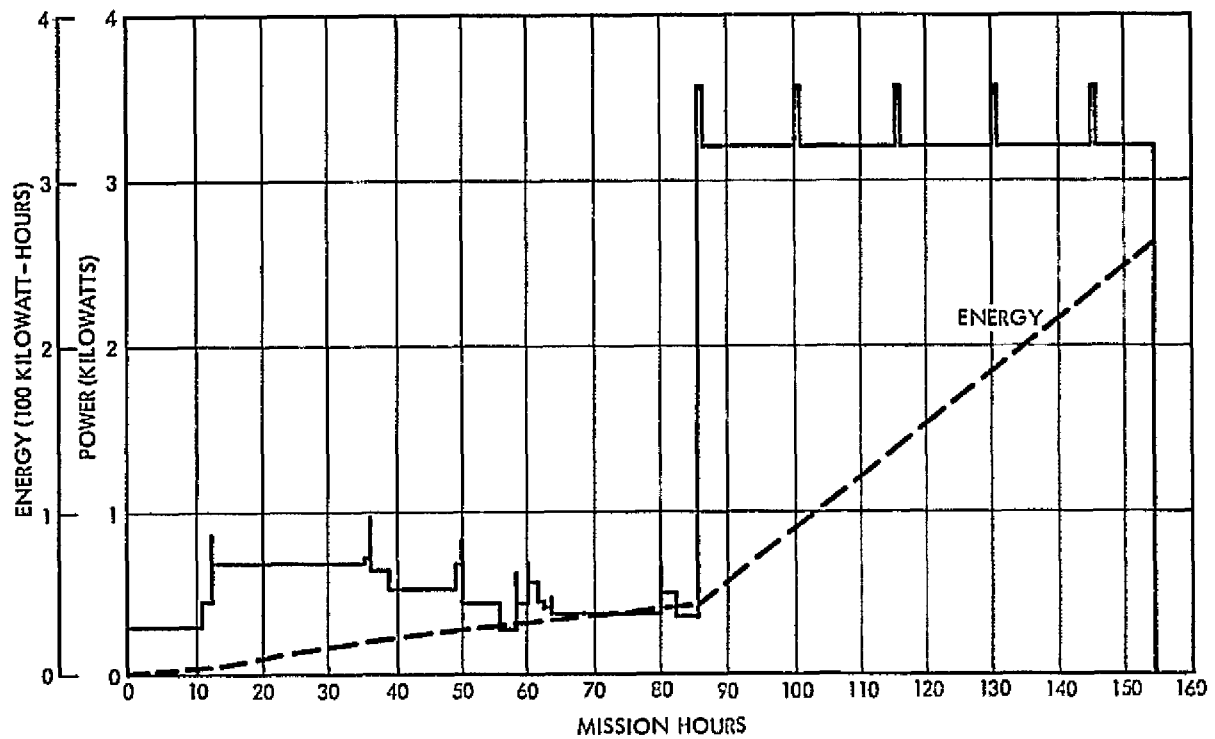


Figure A4.2.1-1. Flight 2 Payload Power and Energy Profile

A4.2.3 Data handling

A4.2.3.1 AMPS flight 2 configuration. The AMPS Flight 2 Spacelab CDMS configuration for the Orbiter AFD and the Spacelab module is similar to that for Flight 1 and is not repeated here. However, different instruments used in this flight required minor modifications to the pallet data handling configuration. The RAU utilization for Flight 2 is slightly higher than Flight 1 because of a more complex payload on Flight 2. However more than adequate margin exists for future growth capability.

A4.2.3.2 Data formats. Flight 2 consists of 10 individual experiments. The data handling requirements on an experiment basis are presented for Flight 2 in Table AIV.II.III-1. Examining these data handling requirements, Flight 2 can be accommodated with two digital formats and one analog format. The data format requirements for Flight 2 are shown in Table AIV.II.III-2. Format 2A can support any one of the high data rate experiments (minor constituents, D-region composition, anomalous composition, or high altitude ozone) plus the low data rate oxygen variation and solar flux radiation experiment simultaneously. Format 2B can support any two of the four medium data rate experiments (conductivity modification, HF wave particle interaction, long delay echoes, and plasma flow) simultaneously plus the low data oxygen variation and solar flux radiation experiments. Format 2C is similarly used to accommodate the video signal that is generated by the OBIPS in support of certain experiments.

Table AIV.II.III-1. Data Requirements for Flight 2

Experiments	Maximum Data Requirements		Comments
	Digital	Analog (MHz)	
Conductivity modification	17.4 kbps	4.2	Analog signal is video from optical band imager
HF/wave particle interaction	17.3 kbps	-	
Long delay echoes	17.3 kbps	-	
Plasma flow	17.2 kbps	4.2	
Minor constituents	2.57 Mbps	-	Highest data rate
D-region composition	2.57 Mbps	-	
Oxygen variation	10.2 kbps	-	
Anomalous composition	2.57 Mbps	4.2	
High altitude ozone	2.57 Mbps	-	Highest data rate
Solar flux radiation	3.2 kbps	-	Performed 30 minutes once per day

Table AIV.II.III-2. Flight 2 Experiment Data Format Requirements

Experiments	Format No.		
	2A (2.6 Mbps)	2B (49 kbps)	2C (4.2 MHz)
1) Conductivity modification		x	x
2) HF wave particle interaction		x	
3) Long delay echoes		x	
4) Plasma flow		x	x
5) Minor constituents	x		
6) D-region composition	x		
7) Oxygen variation	x	x	
8) Anomalous composition	x		x
9) High altitude ozone	x		
10) Solar flux radiation	x	x	

A4.2.4 Software. This section describes the software functions that must be performed in support of the AMPS Flight 2 payload by:

- (a) The Orbiter computers and master timing unit
- (b) The Spacelab subsystem computer.

A4.2.4.1 Orbiter computer support. No additional Orbiter software support is required for AMPS Flight 2.

A4.2.5 Pointing and control. The major pointing and control requirements placed on the Spacelab and Orbiter is for an experimental pointing mount. This requirement results from the fact that a large number of the instruments included in the AMPS payload require either: 1) a large field of view or motion relative to other body fixed instruments, 2) fine pointing to accuracies better than Orbiter can provide (i.e., approximately 2 degrees) or rate stabilization over selected periods better than Orbiter can provide (i.e., approximately 0.01°/sec).

A4.2.5.1 Many NASA studies have shown that the most cost effective way to meet these requirements is with an independently gimballed pointing mount. These experiment pointing mount requirements are not unique to AMPS and have been recognized by NASA for general payload support. As a result, preliminary work has been done on several designs and a decision on which EPM design to support is planned by NASA. The most likely candidate appears to be the small instrument pointing system (SIPS) which forms the basis of the baseline design.

A4.2.6 Stowage. The Orbiter/Spacelab stowage requirements defined for the AMPS Flight 1 are adequate for Flight 2.

A4.2.7 OMS/RCS propellant usage. The OMS and RCS propellant usage is based on the attitude changes and maneuvers required for orbital operations and the pointing required for each experiment. Requirements are summarized below.

	RCS (kg)	OMS (kg)
Capacity	3,353	11,377
Utilization		
• Nominal	2,054	8,946
• Dispersions	136	
• Reserves		561
• Unavailable	366	256
Total	2,556	9,763
Margin	797	1,614
% Margin	24	14

A4.2.8 Controls and displays. The Orbiter/Spacelab controls and displays required in support of the AMPS Flight 2 payload are the same as for Flight 1.

A4.3 SPACELAB/ORBITER INTERFACE REQUIREMENTS. The analyses, tests, test results, hardware, software, and other supporting data described in 4.3 is also required for Flight 2.

A4.4 COMMUNICATION AND DATA REQUIREMENTS. The communication and data handling subsystem described in 4.4 is adequate for AMPS Flight 2 except for the on-board data processing. Changes to on-board data processing are described in A4.4.7.

A4.4.7 On-board data processing. This section describes the functions performed by the on-board AMPS flight software application programs servicing Flight 2. Table (TBS) presents these requirements.

A7. FLIGHT CREW REQUIREMENTS

A7.1 CREW SIZE. The size and functions of the flight crew required to perform the requirements of this flight are shown in Table AVII.I-1.

Table AVII.I-1. Flight Crew Requirements

Flight Crew Functions	CDR	Pilot	Mission Spec	Payload Spec	Payload Spec
<u>Orbiter Flight Operations</u>					
Vehicle flight control	P	B			
Guidance, navigation	P	B			
Vehicle systems management	P	B			
Monitor, control flight safety items	P	B			
Consumables management	P	B	S		
Monitor caution and warning	P	B			
Electrical power management	P	B			
Environmental control	P	B			
<u>Payload Operations Management</u>					
Orbiter/payload subsystem checkout, operation			P		
Monitor payload caution and warning			P		
Manage payload support communications			P		
Activity scheduling	S	S	P	S	S
<u>Experiment Operations</u>					
RF sounder			S	P	B
Small instrument pointing				P	B
OBIPS			S	P	B
Vector magnetometer			S	P	B
Barium canister release	S	S		B	P
Optical instruments				B	P
IR radiometer				B	P
IR interferometer spectrometer				B	P
LIDAR				B	P
Environmental sensing package - 1			S	P	P
Environmental sensing package - 2				P	B
Solar flux monitor				S	P
Test body/mast				B	P
Remote manipulator			P		

P - Primary function

B - Backup function

S - Support function

A7.2 PAYLOAD SPECIALIST QUALIFICATIONS. The payload specialist is responsible for the attainment of experiment objectives. In this role, he is responsible for the management of the payload operations, proficient in experiment performance and knowledgeable in the operation of the caution and warning systems, hatches, tunnel and life support systems. In addition to these general characteristics,

the payload specialists for each AMPS flight will have specific scientific training and experience. Each payload specialist should be an experimental physicist, one with a background in ionospheric physics and the other in atmospheric physics.

- A7.3 AMPS TRAINING REQUIREMENTS. Payload specialist training requirements established for Flight 1 are adequate for Flight 2.
- A7.4 TRAINING EQUIPMENT REQUIREMENTS. The equipment required to accomplish the AMPS training plan for Flight 1 is satisfactory for Flight 2.